



Heat pumps in the United States: Market Potentials, Challenges and Opportunities, Technology Advances

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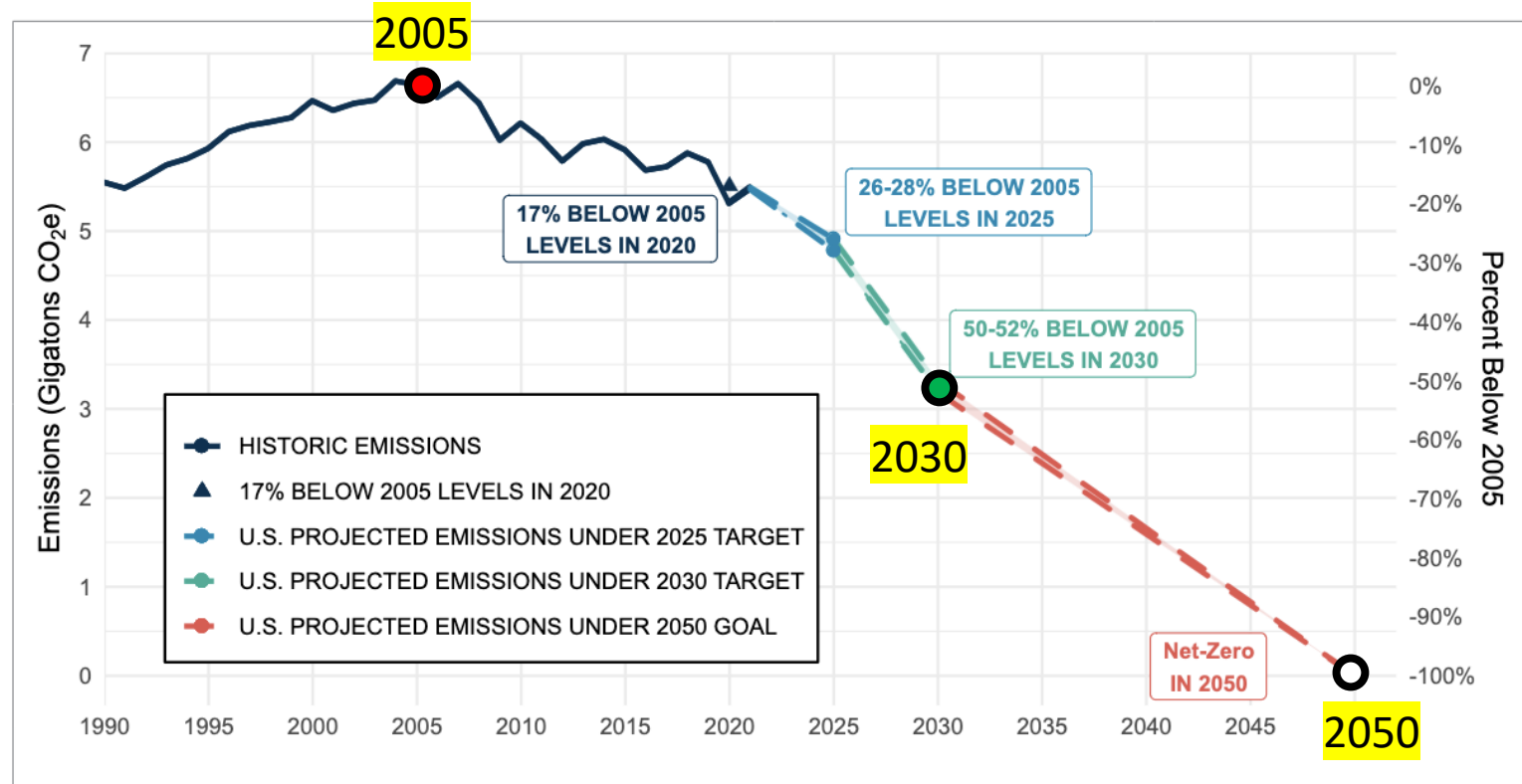
- US Policies and Programs
- Heat Pump Market
- Economic Factors
- Efficiency Standards
- Current R&D Focus
- Summary and Outlook



US Goals



- Reduce GHG emissions by 50%–52% from 2005 levels in 2030
- 100% carbon pollution-free electricity by 2035
- Net-zero emissions economy-wide no later than 2050



United States historic emissions and projected emissions under the 2050 goal for net-zero.

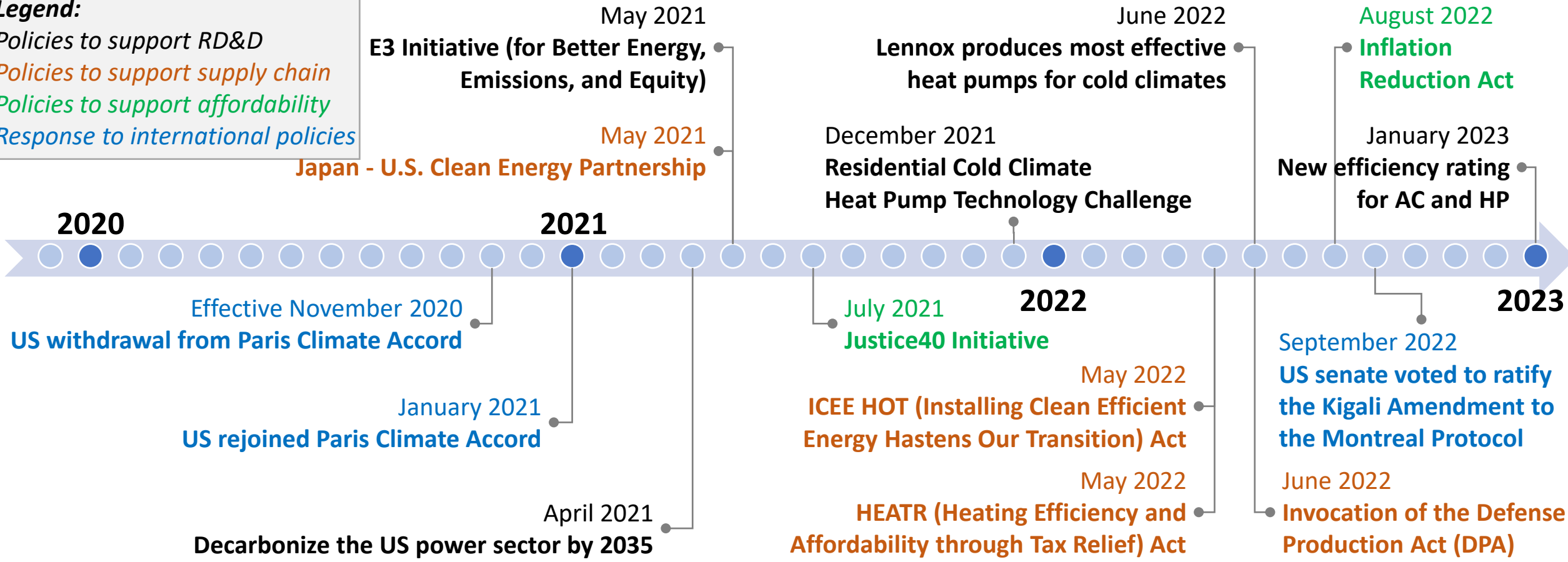
Source: *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050*. November 2021. [whitehouse.gov](https://www.whitehouse.gov)



US Policies and Programs



Legend:
Policies to support RD&D
Policies to support supply chain
Policies to support affordability
Response to international policies



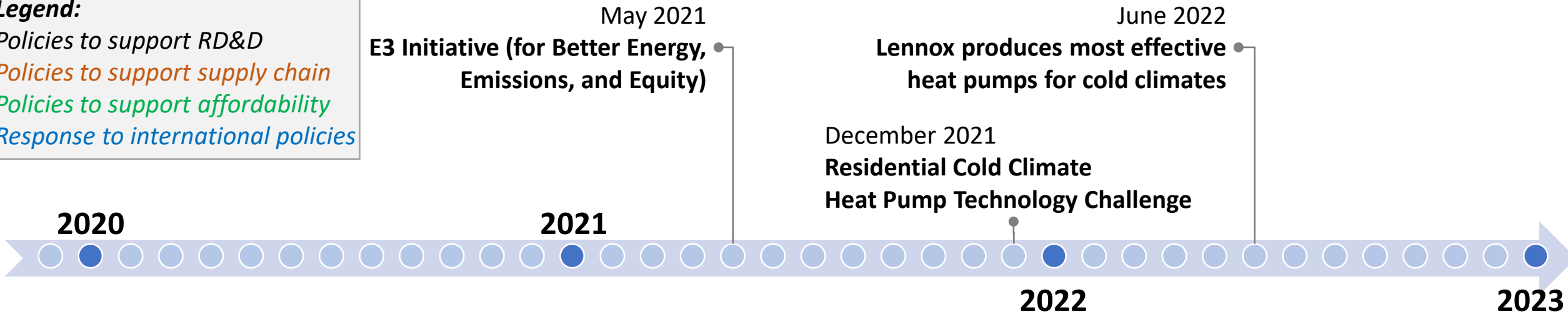
Source: whitehouse.gov; US Department of Energy



US Policies and Programs



Legend:
Policies to support RD&D
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Policies to support affordability
Response to international policies



- E3 Initiative (Initiative for Better Energy, Emissions, and Equity)**
- Advanced Water Heating Initiative
 - Residential Cold Climate Heat Pump Technology Challenge
 - Collaborative RD&D on low to no-GWP refrigerants
 - Residential HVAC Smart Diagnostic Tools Campaign
 - Better Buildings Low Carbon Pilot

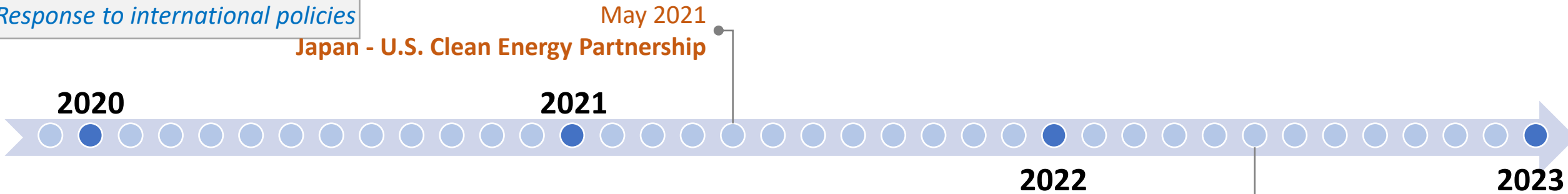
Source: whitehouse.gov; US Department of Energy



US Policies and Programs

Legend:

- Policies to support RD&D*
- Policies to support supply chain*
- Policies to support affordability*
- Response to international policies*



May 2021
Japan - U.S. Clean Energy Partnership

The Defense Production Act (DPA) allows the president to direct resources to ensure the supply of materials and services necessary for national defense.

DPA was invoked in June 2022 to rapidly expand US manufacturing of five critical clean energy technologies, including heat pumps.

June 2022
Invocation of the Defense Production Act (DPA)

Source: [whitehouse.gov](https://www.whitehouse.gov); US Department of Energy



US Policies and Programs

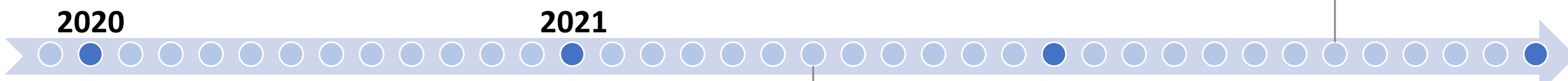


Legend:
Policies to support RD&D
Policies to support supply chain
Policies to support affordability
Response to international policies

Inflation Reduction Act of 2022 aims to curb inflation by

- Lowering health care costs
- Reducing the federal deficit
- Investing into domestic clean energy production and manufacturing

August 2022
Inflation Reduction Act



July 2021
Justice40 Initiative

Justice40 Initiative aims to direct 40% of the overall benefits of certain federal investments, including clean energy and energy efficiency, toward disadvantaged communities.

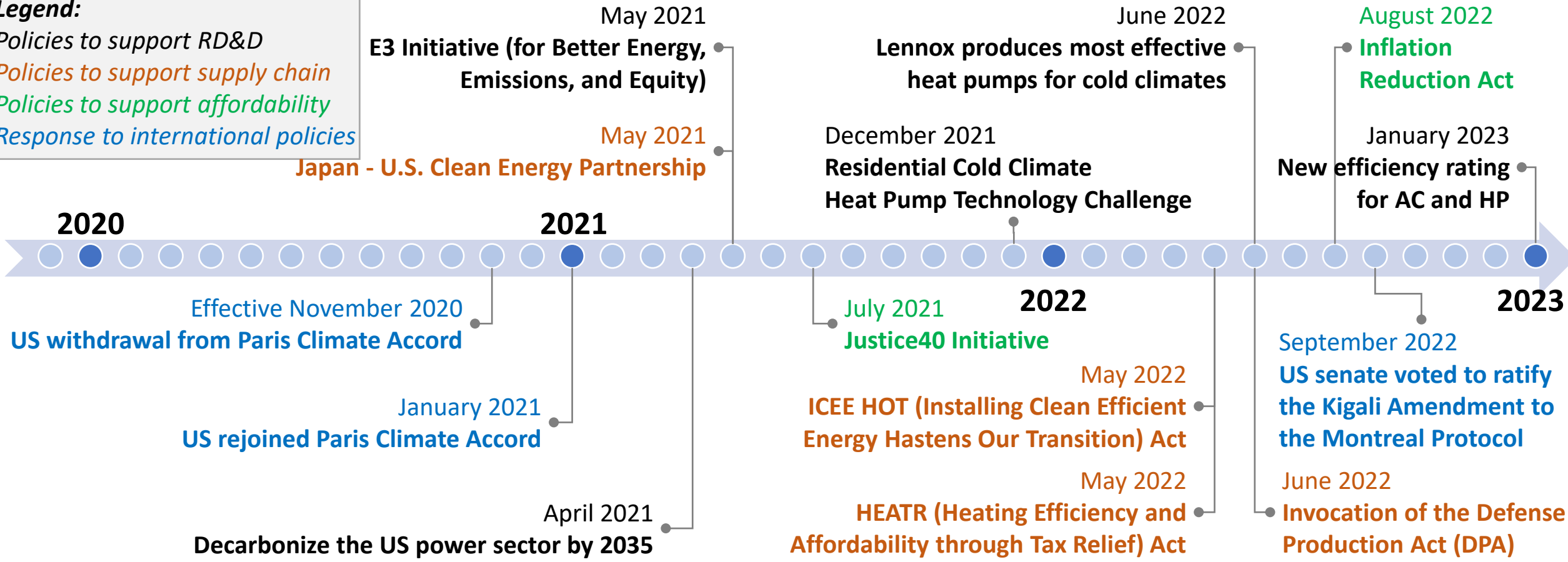
Source: [whitehouse.gov](https://www.whitehouse.gov); US Department of Energy



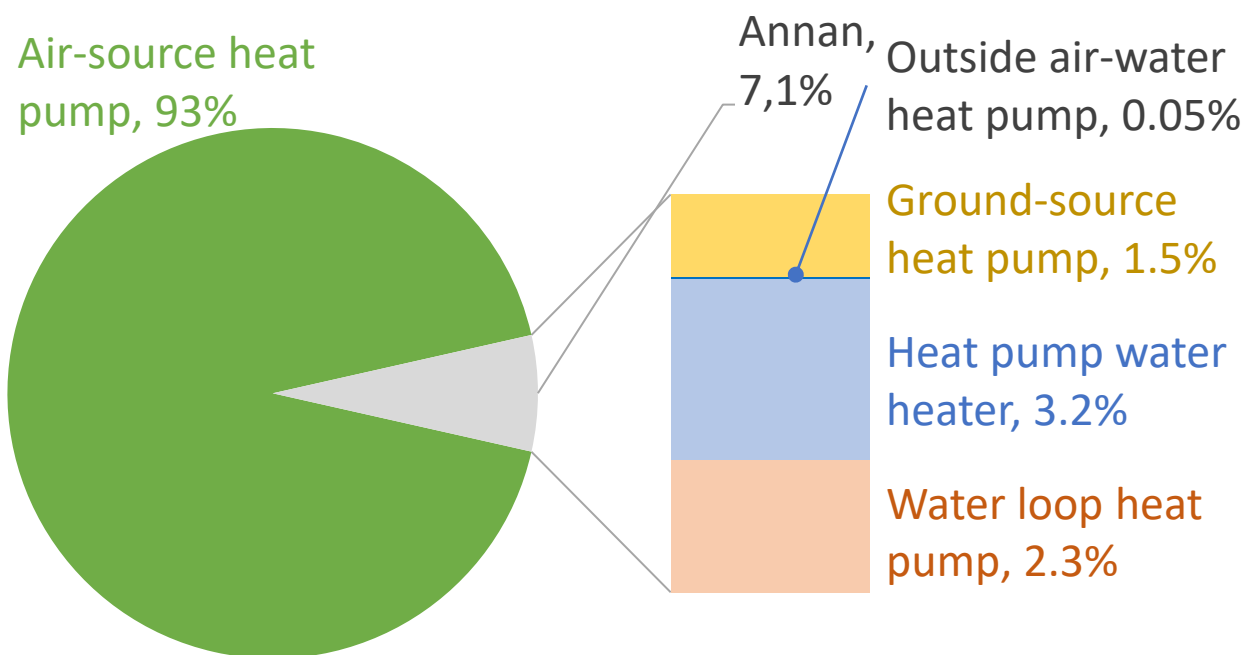
US Policies and Programs



Legend:
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Source: whitehouse.gov; US Department of Energy

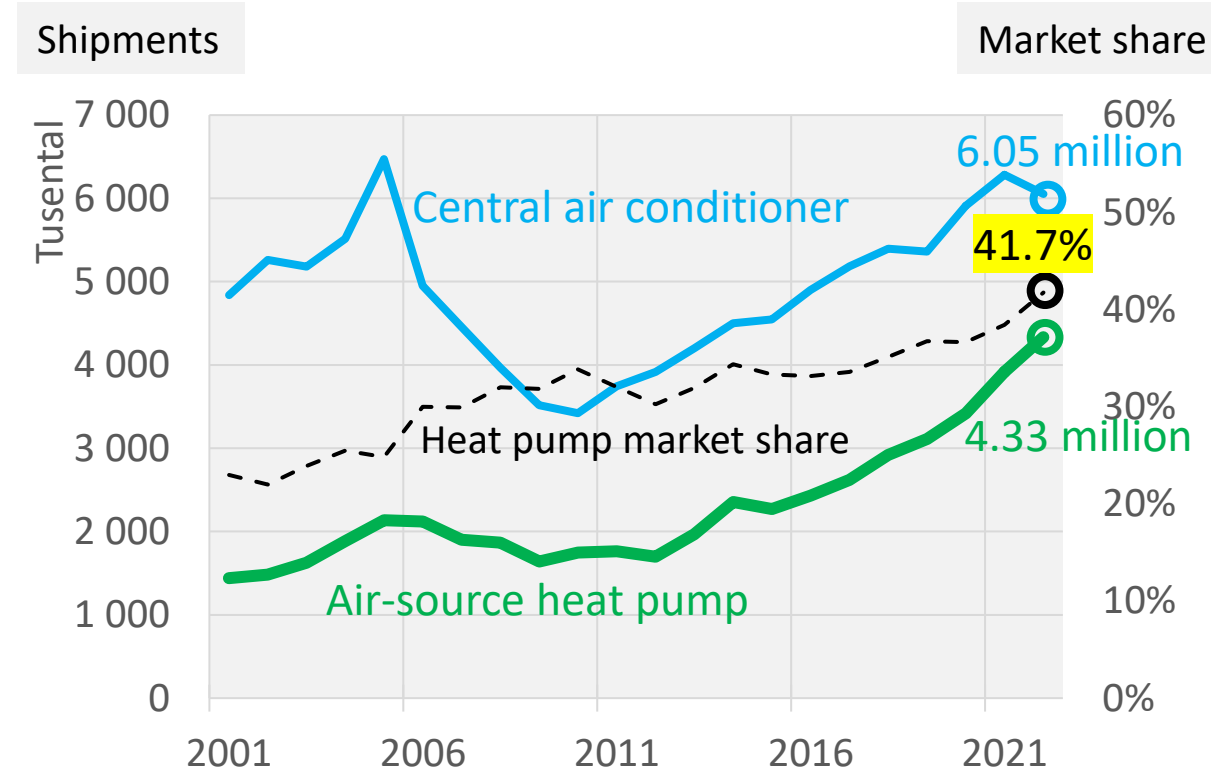
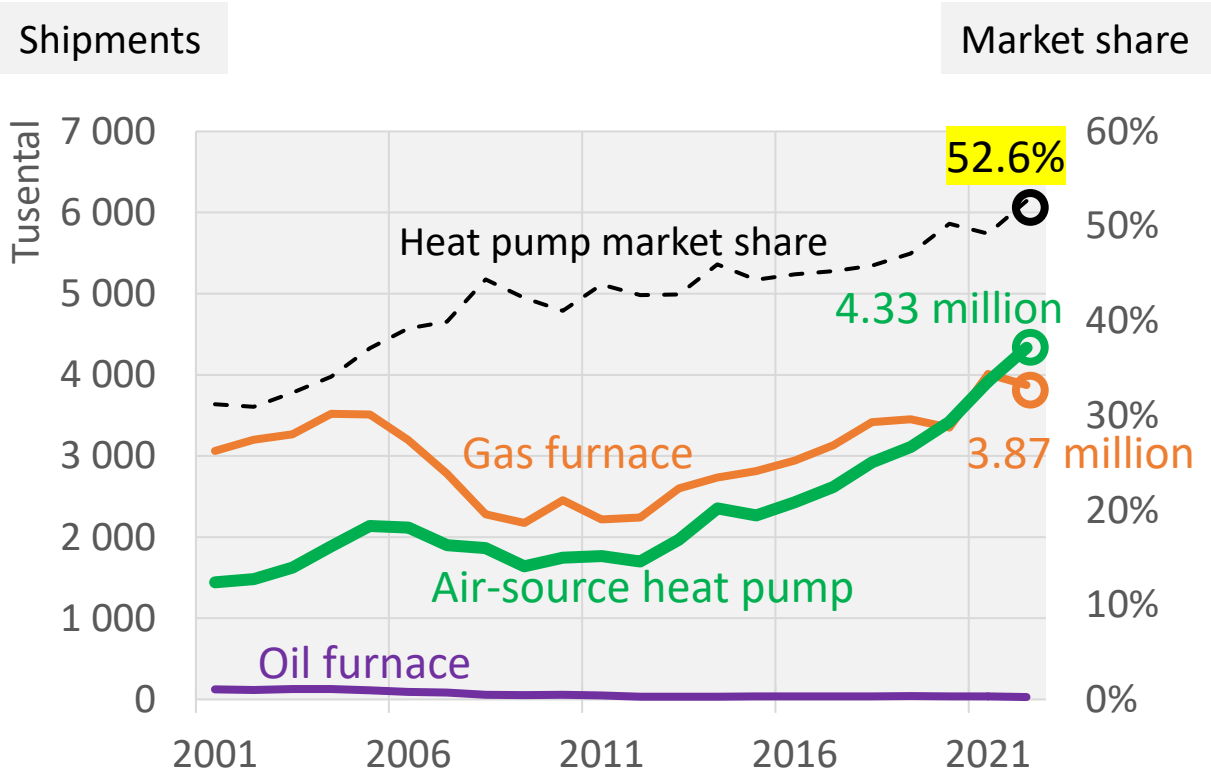


2022 market distribution of heat pump technologies.

- US heat pump market shipments predominantly comprises air source heat pumps (ASHP)
- Heat pump water heaters (HPWH), water loop heat pumps (WLHP), and ground source heat pumps (GSHP) comprised over 7% of heat pump sales in 2022



Air-Source Heat Pump Shipments

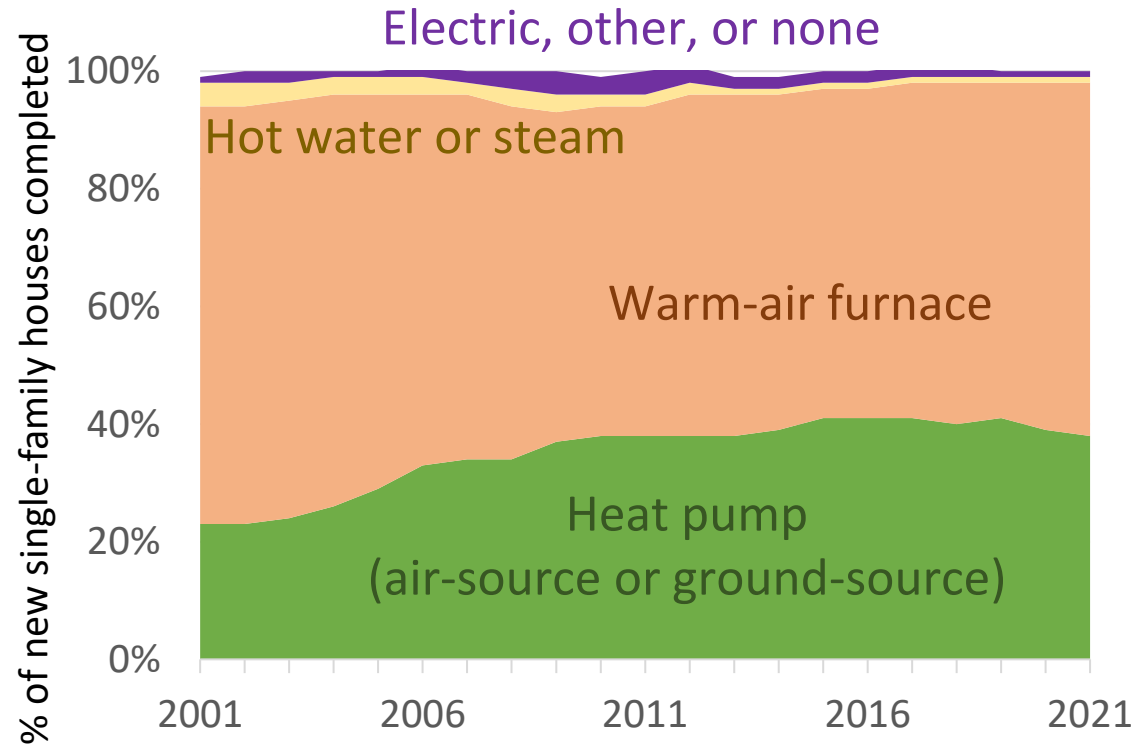


ASHP shipments compared with furnaces and central air conditioners.

Source: The Air-Conditioning, Heating, and Refrigeration Institute (AHRI). Historical Data. <https://www.ahrinet.org/analytics/statistics/historical-data>

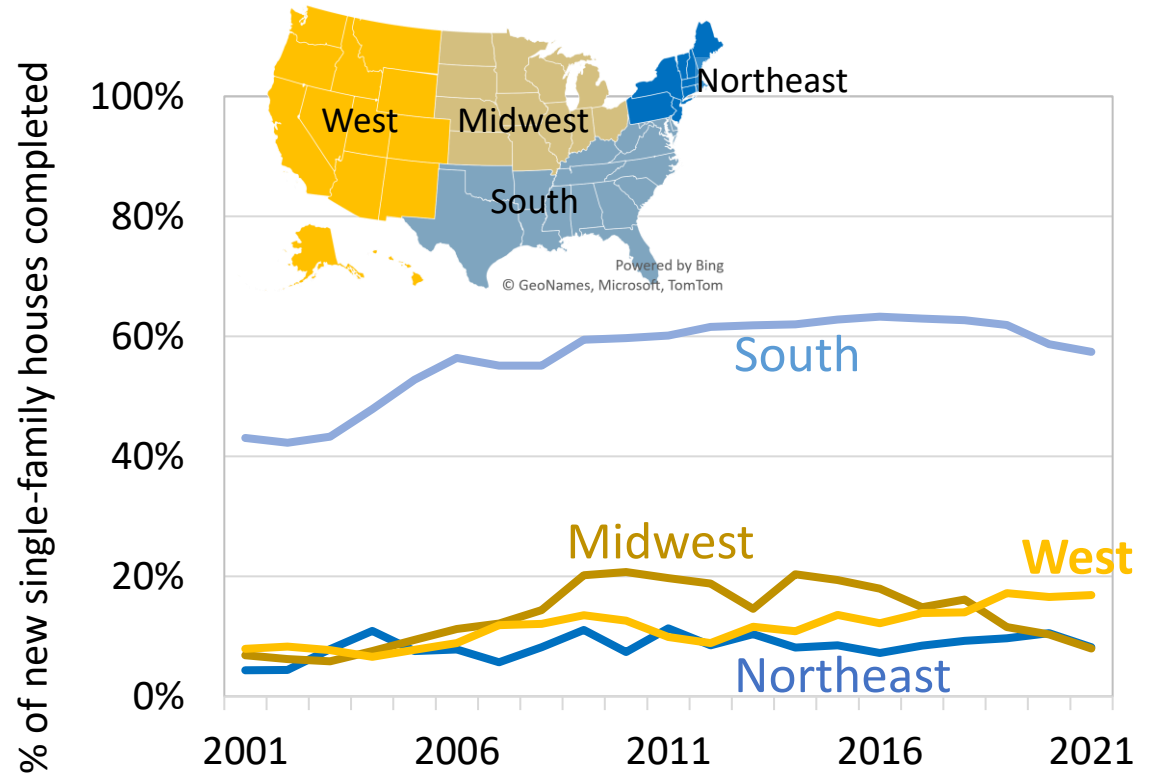


Heat Pump Market Share



38% of new single-family homes completed in 2021 in the US used a heat pump as their primary heating source.

Source: US Census Bureau



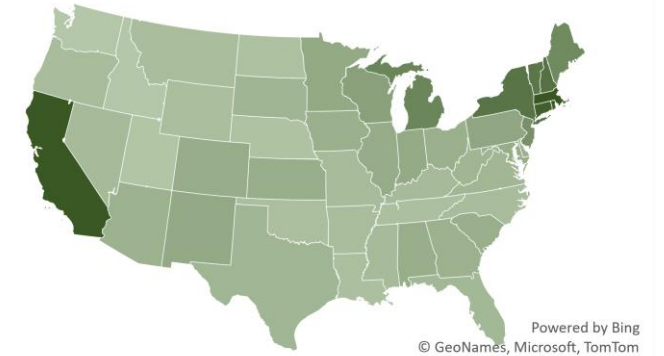
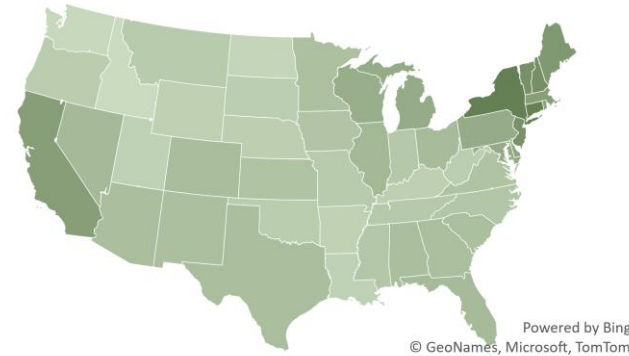
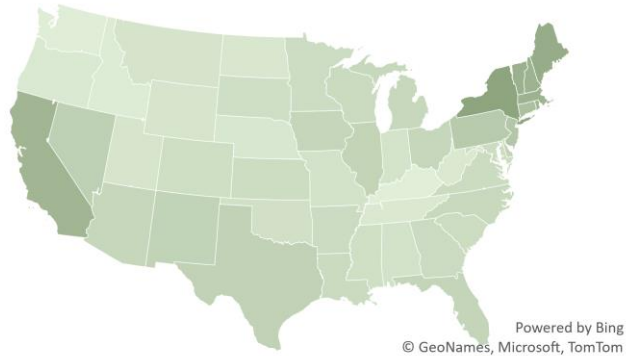
Most of these heat pump installations are in the South.



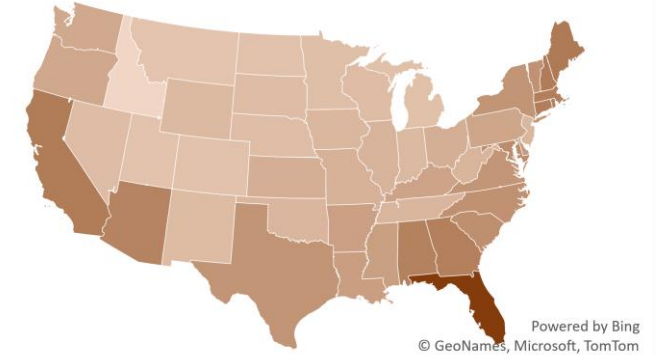
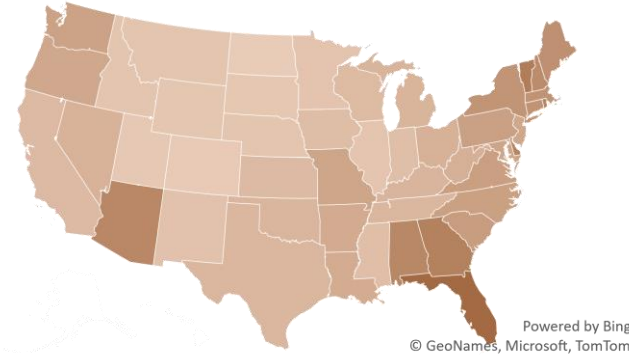
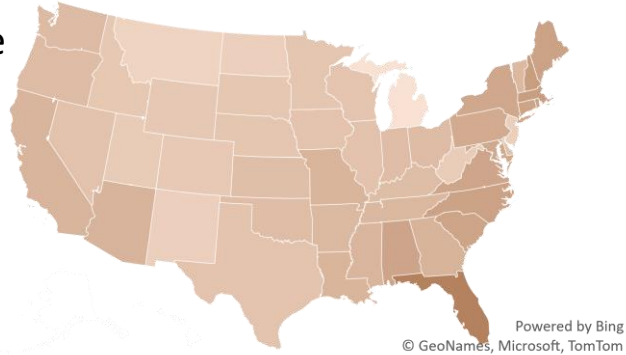
Energy Prices



Electricity Price (cents/kWh)



Natural Gas Price (\$/1000 cuft)



2001

2011

2021

The regional differences in the heat pump market share can be attributed to the mild winter combined with lower electricity and higher natural gas prices in the southern states.

Source: US Energy Information Administration



Financial Incentives



Inflation Reduction Act of 2022

- Tax credits of \$300 for installing ASHP and HPWH in existing homes that meet specified efficiency criteria
- Rebates of 50%–100% up to \$14,000 on electrification measures for low- and moderate-income households

Renewable energy tax credits

- Tax credits of 22%–30% of system cost for GHP installation in existing homes and new construction

Rebate programs by states

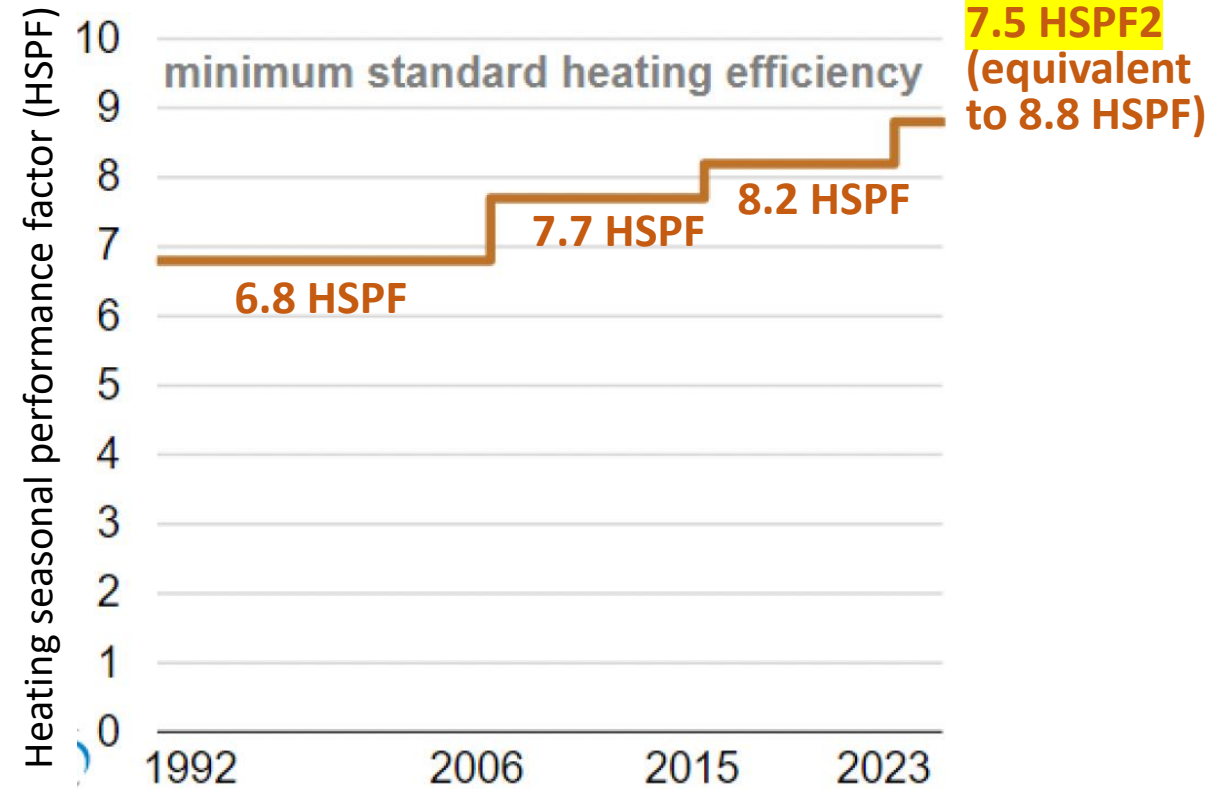
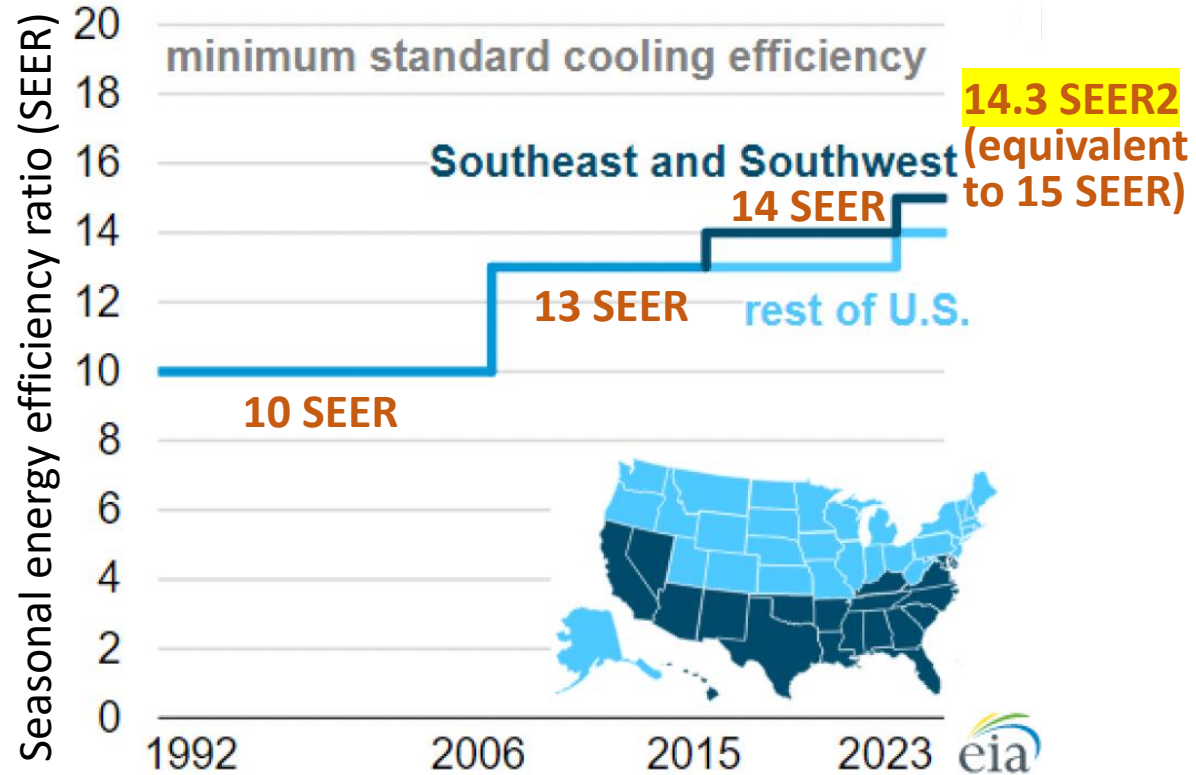
- For ASHP and GHP installation

Loan programs, grant programs, and Property-Assessed Clean Energy (PACE) financing

Source: Energy Star; Database of State Incentives for Renewables & Efficiency (DSIRE); US Department of Energy



Efficiency Standards



Performance standards of residential central **air conditioning equipment** and **heat pumps**.

Source: US Energy Information Administration, <https://www.eia.gov/todayinenergy/detail.php?id=40232#>



Research Challenges and Opportunities

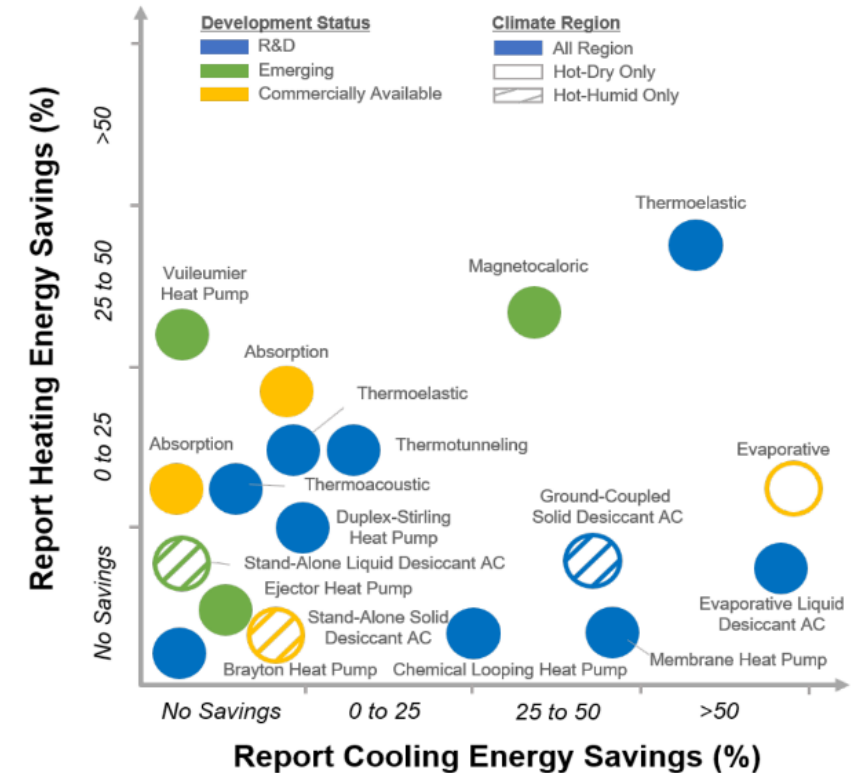
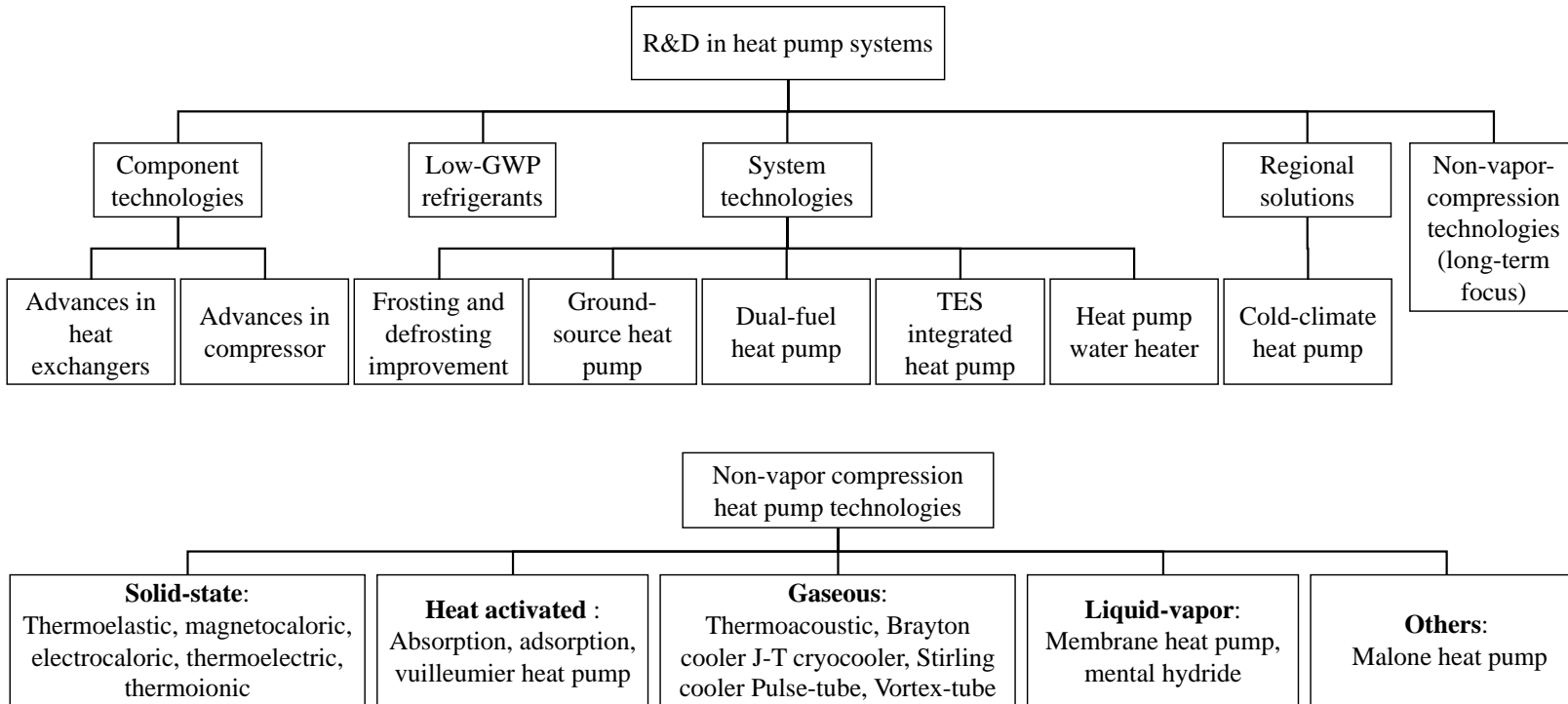


Improve efficiency and capacity of heat pumps for cold climates, and efficiency of systems for warm climates

Reduce installed cost and improve reliability of high-efficiency systems

Develop solutions for problematic heat pump installations, particularly for retrofit and renovation applications

Develop alternative refrigeration technologies and lower-GWP refrigerants to reduce direct emissions



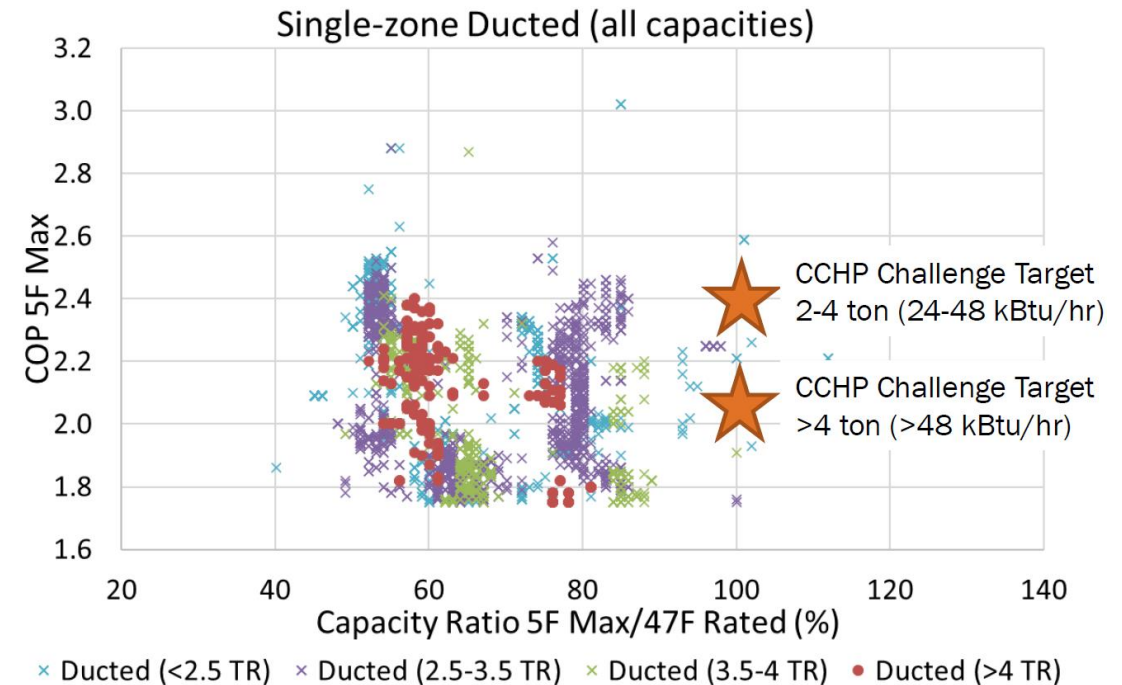
Energy saving potential for different non-vapor compression technologies reorganized based on DOE/EE-1703



DOE's Cold Climate Heat Pump Challenge



- Residential, centrally ducted, electric-only HPs that perform better than today's products
 - Nominal cooling capacity 24,000 – 65,000 Btu/hr, strong capacity maintenance (i.e., 100% heating capacity at 5°F, strong performance to below 0°F)
 - Perform efficiently in cold climates: COP lower limit @5 °F
2.4 (>4 ton) or 2.1 (2-4 ton)
 - Employ low-GWP refrigerants (< 750 GWP, AR4 100 year)
 - Incorporate advanced controls and grid-interactive capability to assist with installation, fault detection, demand response, and other activities (AHRI 1380)



Full specification and test procedure for CCHP Challenge:
<https://www.energy.gov/eere/buildings/residential-cold-climate-heat-pump-challenge>



Summary and Outlook



- The **market** growth is uneven geographically (i.e., very small market share in cold climates)
- **Hurdles** for heat pump deployment include:
 - High cost of installation; high operational costs in cold climates
 - Supply chain constraints
 - Existing building stock with fossil fuel systems and constraints for fuel-switching
 - Need for supplemental electric resistance heating; overstress for the existing grid
- A large increase in heat pump **policies and incentives** for advancing heat pump RD&D
- **Research** efforts have significantly improved the energy efficiency of heat pumps; To further expand the usage of heat pumps, need to improve performance and reliability while discovering novel applications
- As the share of renewables in the energy mix increases, heat pumps can play an important role in electrifying the building sector



Thank you!

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